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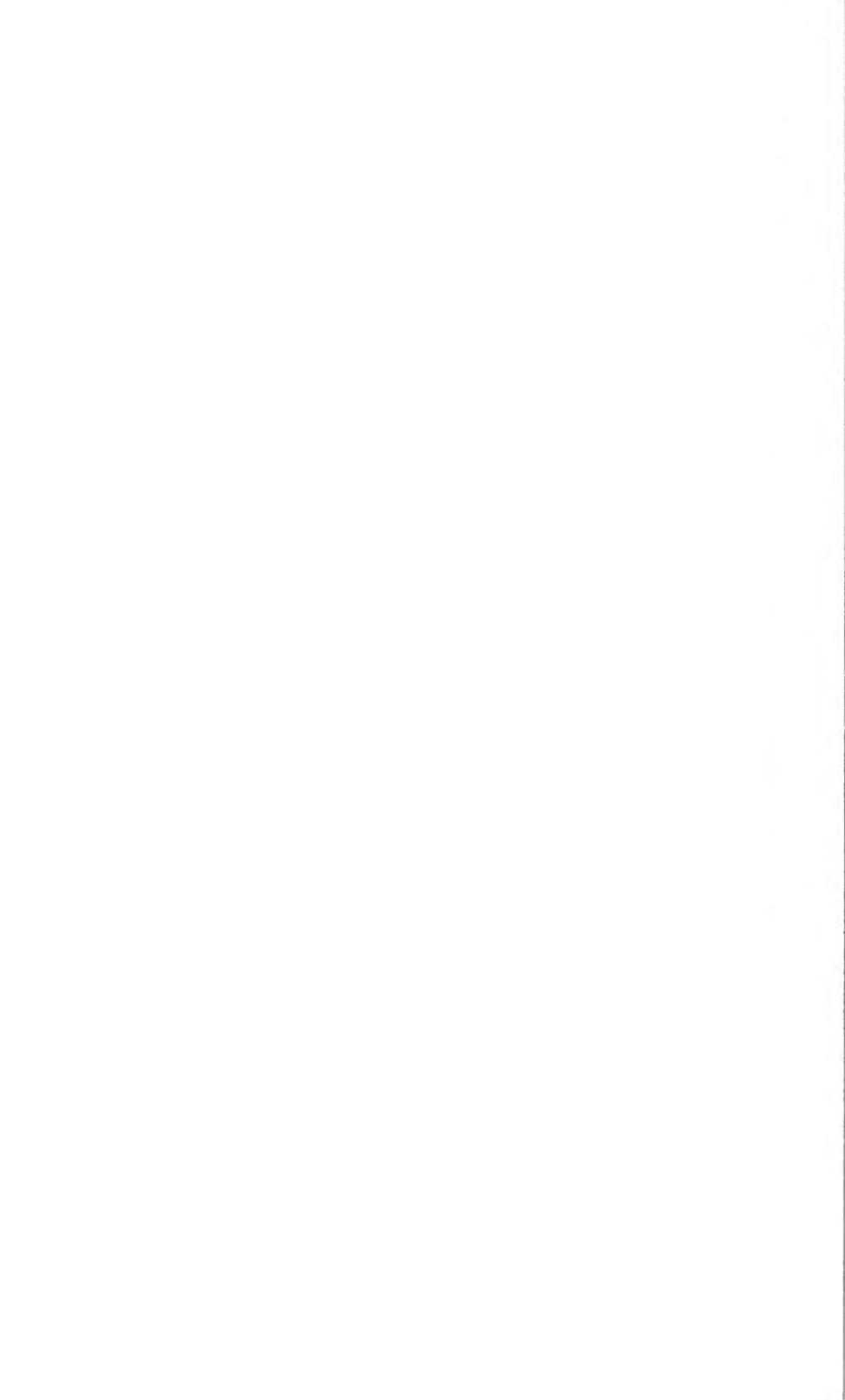
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Some Factors Influencing the Keeping Quality of Fruit In Transit

By J. W. LLOYD and H. M. NEWELL



UNIVERSITY OF ILLINOIS
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SOME FACTORS INFLUENCING THE KEEPING QUALITY OF FRUIT IN TRANSIT

By J. W. LLOYD, Chief in Olericulture, and H. M. NEWELL, Associate
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THE CONDITION of fruit at the time it is offered for sale in the wholesale city markets is an extremely important factor in determining its market value. No matter how perfect the specimens may have been when gathered in the field or orchard, if they arrive in the market in an overripe, bruised, or decayed condition, their value is greatly depreciated. Therefore, all factors which have a bearing upon the keeping quality of fruit during the harvesting and marketing processes are of importance.

The results of various tests in the refrigeration of Illinois fruits in transit have already been published.¹ Some factors other than refrigeration during transit, that may have an important effect upon the condition of fruit on arrival in market are care in handling during the harvesting and preparation of the product for market, delay in getting the fruit under refrigeration, and type of package used.

DISCUSSION OF LITERATURE

Importance of Careful Handling

It is quite generally admitted that careful handling of fruit is advisable, and there is much experimental evidence and practical experience in support of this view.

The classical work of Powell^{14*} showed that the decay of oranges in transit was due principally to clipper cuts, stem punctures, and other mechanical injuries received during picking and packing. In an orchard where from 20 to 25 percent of the fruit had usually been injured during picking, careful handling was instituted and the injury reduced to 1 to 3 percent.

Mann^{11*} reported five series of experiments made with Flame Tokay grapes handled by careful workers and by careless workers in the same picking crews. The grapes handled by careless workers showed from three to seven times as much deterioration as those handled by the careful workers, after being held 12 days in a refriger-

¹Observations on the refrigeration of some Illinois fruits in transit. Ill. Agr. Exp. Sta. Bul. 334. 1929.

ator car and seven days in a produce room under conditions similar to those in the market.

Tests reported by Ramsey^{15*} in the handling of red raspberries showed that carefully handled berries held in a refrigerator car for eight days developed only 2.2 percent of decay while comparable lots of commercially handled berries developed 26.7 percent of decay. Wide differences in the results obtained by different growers in the handling of their berries were observed by Ramsey. Inspection of the fruit handled in their customary manner by twelve different growers showed decay varying from 1.3 percent to 39 percent. The differences were due mainly to the character of the work required by the owner from his help.

Ramsey^{16*} also reported the results of tests to determine the effect of careful handling on the keeping quality of sweet cherries. The cherries were held in a refrigerator car on track for 10 days. At the end of that period the carefully handled fruit showed only 1.5 percent of decay while commercially handled fruit showed 12.3 percent of decay. Two days after withdrawal from the car, and held under ordinary market conditions, the carefully handled fruit showed only 3.5 percent of decay, while the commercially handled fruit showed 21.4 percent. Striking results were also obtained by Ramsey in similar tests with fresh prunes. Carefully handled prunes showed only .4 percent decay after 15 days in a refrigerator car; while commercially handled prunes showed 7.1 percent decay. Six days after withdrawal, the carefully handled fruit showed 3.7 percent decay and the commercially handled 16.6 percent.

Work by Brooks and Cooley^{**} indicates that germinating spores of Rhizopus rot seldom if ever penetrate the sound skin of market-ripe peaches, and that Monilia spores are a source of infection chiefly when aided by bruises, punctures, and similar favoring conditions.

Effect of Delay in Cooling

Many tests have shown that fruit softens and deteriorates very rapidly after being picked unless promptly placed where the temperature is low. Appleman and Conrad^{2*} tagged a number of hard-ripe Crawford peaches on the tree. One lot was picked and stored at 37.6° F., another lot was placed in a constant temperature chamber at 72° F., and a third lot was left on the tree. The outdoor temperature the next few days showed an average daily mean of 60° F. At the end of three days the peaches that had been left on the tree and also those that had been held at a temperature of 37.6° F. were still hard; but those that had been kept at 72° F. were very soft. Duruz^{4, 5*} has stated that the ripening process in apricots, plums, and peaches continues at a faster rate after picking than before, especially while

the fruit remains warm. Hartman *et al*^{7, 8*} say that at the temperatures prevailing at harvest time, pears ripen much faster after picking than they do while attached to the tree. Magness *et al*^{10*} have reported that the rate of softening of apples while the fruit remains on the tree is considerably less than that following picking if the fruit is held at prevailing orchard temperatures. Powell^{14*} advised leaving oranges on the trees until they could be shipped rather than picking them and leaving them in the packing house several days before shipment.

In tests by Ramsey^{16*} commercially handled cherries delayed two days before loading into a refrigerator car showed 25.4 percent decay in 10 days, while similar cherries immediately loaded showed 13.5 percent decay in the same time; and carefully handled prunes delayed two days before loading showed 4.0 percent decay after 10 days, while the immediately loaded fruit handled in the same way showed only .4 percent decay.

Brooks and Cooley^{3*} found that the rotting of peaches was greatly accelerated by delay in reducing the temperatures. With peaches that were punctured and then dusted with *Rhizopus* spores, a delay of 24 hours at a temperature of 25° C. before storing at 7.5° C. gave the rots a lead of 5 days over similar inoculations on peaches that were delayed but 12 hours before storing at the same temperature.

In the handling of red raspberries Ramsey^{15*} found that while in certain lots loaded immediately after picking there was 7.1 percent of decay after 4 days in the car, other lots of similar fruit that were not loaded until the afternoon of the day following picking showed 27.7 percent of decay.

Allen, Magness, and Haller^{1*} found that most of the varieties of plums they studied softened about as much during 6 days at 52° F. as they did in 12 days at 43° F. They urged the necessity of getting plums under refrigeration as quickly as possible after picking, since at 70° F. or above, the temperatures usually prevailing during the harvest season, the fruit softened very rapidly after removal from the tree.

Magness^{9*} advised warehouse cooling of Bartlett pears for 36 to 48 hours at a temperature of 28° F. immediately after picking; then transferring to a room held at 40° F., where the fruit is graded and packed; then returning the fruit to a 28° room for storage. This was considered preferable to delaying the refrigeration of the fruit until after it could be graded and packed.

The unfavorable effects of delay in refrigeration are very forcibly brought out in various tests in the handling of fruit for storage. Hartman *et al*^{7*} found that in the handling of Bose pears a delay of 7 days at a temperature of 66° F. before placing in cold storage was

responsible for a reduction of at least two months in the storage life of the fruit. Magness^{9*} found that Bartlett pears could be held fully ten times as long in storage at 30° as at 60° F.; while Overholser and Latimer^{13*} found that the average maximum keeping period of four varieties of pears, d'Anjou, Comice, Bosc, and Howell, at 30° F. was 143 days, while at 45° F. the average maximum keeping period was 37 days.

Magness *et al*^{10*} made a detailed study of the comparative softening rates of a number of varieties of apples at different temperatures. They found that in most varieties one day at 70° F. will soften the fruit approximately as much as 2 days at 50°, 4 days at 40°, 8 to 10 days at 32°, or 12 days at 30°; and stated that if the weather is warm at picking time, every day's delay in cooling the fruit will reduce the possible storage life 8 to 10 days.

Tests by Morris^{12*} showed that Rome Beauty apples softened more rapidly in the first 24 hours of high temperature (75 to 80° F.) storage than in any succeeding period of time similar in length.

Since prompt cooling of fruit to a low temperature is desirable, there is much advantage in having the fruit as cool as possible when it is picked. Thomsen and Thorne^{17*} have advised picking strawberries early in the morning while they are cool, even tho wet with dew. Hartman and Bullis^{8*} found that sweet cherries were apparently much softer and more susceptible to mechanical injury when warm than when cool. Ripe specimens of the Napoleon variety were 29.9 percent softer at 90° F. than at 32° F. They advised that whenever possible the picking be done in the morning while the fruit is cool from the night temperatures.

While prompt cooling of fruit is recognized as essential to the safe carriage of the more perishable types to market and to long keeping of the less perishable types in storage, the work of Ramsey^{15, 16*} and Powell^{14*} has clearly shown that precooling of fruits before shipment will not overcome the bad effects of rough handling.

Effect of Type of Package on Carrying Quality

The type of package used may affect the condition in which fruit reaches the market. Even packages that have been recognized as standard containers for given products may not be as well adapted to the safe carriage of the commodity as some other type of package. Ramsey^{16*} found that much of the decay of sweet cherries in transit resulted directly from bruises incurred in packing and facing the fruit in the regular 10- and 20-pound boxes. Trial shipments of cherries in berry crates gave uniformly good results, with practically no bruising.

ILLINOIS EXPERIMENTS

Most of the published accounts of experiments to determine the effects of careful and careless handling, and prompt and delayed loading of fruit have dealt with products grown under irrigation in an arid climate at a long distance from market. With a view to determining the applicability of the same principles to the handling and shipment of Illinois fruits produced in a humid climate closer to market, various tests have been made. These tests have included careful vs. rough handling of strawberries, summer apples, and peaches; prompt vs. delayed loading of the same three commodities; and the use of different types of packages for strawberries and peaches.

Careful Handling Reduced Spoilage of Strawberries

Four tests were made with a view to securing accurate data regarding the effect of careful and rough handling on the keeping quality of strawberries and their condition upon arrival in market after being shipped by rail. These tests were made with berries produced at Villa Ridge, Illinois, and shipped under refrigeration to Peoria, Illinois, or Davenport, Iowa.

In each test one lot of berries was very carefully handled thruout the process of picking the fruit and preparing it for market. The berries were carefully picked by a few pickers especially selected from the regular picking crews and instructed to handle them with all possible care. The boxes of berries were carefully placed in 24-quart crates and allowed to stand in the shade of a packing shed for a short time. The crates of berries were then loaded into a light truck, covered with a tarpaulin, and hauled to the loading point. Particular care was taken to prevent jolting and jarring during the trip.

In contrast to this careful handling, one lot of berries in each test was handled roughly thruout the process of picking and packing. Altho in each instance the berries were picked at the same time and from the same field as the carefully handled lot, the method of picking was entirely different. The berries were pulled roughly from the vines, and a handful at a time was accumulated before the berries were placed in the boxes. The fruit was tossed or dropped into the boxes instead of being placed there gently. The filled boxes were handled carelessly as they were placed in the crates. After that, the handling was the same as in the preceding lot, the crates being left in the shade until loaded and then hauled to town in the same truck.

In two of the tests there was a third lot of berries consisting of crates selected at random from those hauled to the shipping point by the grower from whose field the specially handled lots were secured. In each instance these berries were picked from the same field the same morning as the special lots and were handled in the usual com-

mercial manner. They served as checks on the two other methods of handling. Each lot in the various tests consisted of either two or four crates. All lots in the same test were loaded in the same part of a refrigerator car so that conditions after loading would be as nearly identical as possible. All cars moved under standard refrigeration.

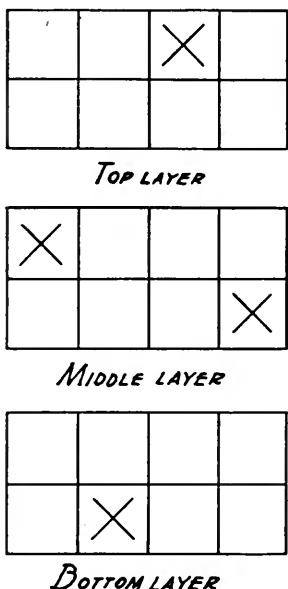


FIG. 1.—LOCATION OF INSPECTED BERRY BOXES IN CRATE

By taking boxes from the same positions in each crate, fairer samples were secured than if the positions of the inspected boxes had not been predetermined.

layers of the crate. The positions of the boxes taken for inspection are indicated in the accompanying diagram (Fig. 1). In making the inspection each box of berries as taken from the crate was weighed, then the berries were poured carefully from the box into a grading pan. The empty box was then weighed. The berries were carefully sorted and all berries showing any decay or softness from bruises were placed in another weighed quart box. The sound berries were returned to the original container as the sorting proceeded. The net weights of sound and of damaged berries from each box were recorded and the percentages calculated for each crate. The percentage of spoiled

Two of the tests were with Klondike berries and two with Aroma. In each test the berries were examined at destination three days after they were picked. In all the tests the general appearance of the carefully handled berries was either good or fairly good upon arrival in market, tho there were a few wilted berries and some rot and mold in bruised berries at the tops of the boxes. On the other hand, the general appearance of the roughly handled berries was either poor or very poor; many of the berries were badly bruised; there was considerable soft rot and mold, and in some instances the decayed berries were sticking together in masses. In the commercially handled berries the general appearance of the fruit was fair or fairly good; there was some soft rot and mold. The condition was between that of the carefully handled and roughly handled fruit.

To determine the percentage of spoiled berries, four boxes from each crate in each lot were inspected in detail. Two boxes were taken from the middle layer and one each from the top and bottom

berries in each lot was determined by averaging the percentages for the various crates in the lot.

The percentage of spoilage in the roughly handled lots was approximately double that in the carefully handled lots (Table 1).

TABLE 1.—PERCENTAGE OF SPOILED BERRIES UNDER DIFFERENT METHODS OF HANDLING

	Klondike		Aroma	
	Test 1	Test 2	Test 3	Test 4
	<i>perct.</i>	<i>perct.</i>	<i>perct.</i>	<i>perct.</i>
Carefully handled....	10.84	8.63	15.65	21.69
Roughly handled....	24.63	20.51	32.40	40.01
Commercially handled		11.34		26.66

Pan Grading Improved Appearance of Strawberries. It has been suggested that part of the spoilage of strawberries apparent upon arrival in market might be obviated by the elimination of inferior or off-condition berries before the fruit is shipped, either by having the pickers grade the berries as they are picked or by pan grading at



FIG. 2.—STRAWBERRY GRADING PAN IN USE

Not more than one quart of berries is placed in the pan at one time. Such a pan can readily be made by a local tinsmith.

the packing shed. Two tests were made to compare grading by pickers with pan grading and with commercial handling; and in three other tests pan grading and commercial handling were compared. The varieties included Klondike, Dunlap, and Aroma.

In the first test Klondike strawberries from Villa Ridge were used. In one lot of these berries the fruit was graded by the pickers as the berries were being picked. The pickers were instructed to pick and place in the boxes only berries of good size and proper degree of ripeness, and to keep all trash and undesirable berries out of the boxes. It was very difficult to find pickers who were able to make much improvement in the grade of berries by field grading. Furthermore, it was almost impossible to get the pickers to adhere consistently to the grading standards desired.



FIG. 3.—INSIDE A COMMERCIAL STRAWBERRY PACKING SHED
Each box of berries is examined before being placed in the crate.

Another lot of berries in this test was pan graded. These berries were picked in the ordinary manner, no attempt being made by the pickers to grade or sort them. They were taken to the packing shed as soon as picked, and there were pan graded before being packed. In this process the boxes of berries were carefully emptied into regular strawberry grading pans (Fig. 2); the small, overripe or damaged berries were removed and the good berries were run back into the boxes. No more than one quart of berries was in the grading pan at a time.

One lot of berries picked and packed in the usual commercial manner was included in this test for comparison. The boxes of berries as brought in by the pickers were placed in the crates with no grading other than that the tops of the boxes were examined for trash, green berries, and overripe berries (Fig. 3).

The berries in this test were included in a carload shipped under standard refrigeration to Minneapolis, Minnesota, where they were unloaded and examined five days after they were picked.

The general appearance of the berries graded by the pickers was good, tho a little bruising was apparent. The general appearance of the pan-graded berries was very good, tho the berries at the tops of the boxes were somewhat bruised. Most of the spoilage in this lot was apparently due to these bruises. The commercially handled berries were in generally good condition, tho considerable bruising was apparent; most of the spoilage was due to bruises.

The fruit graded by the pickers showed less spoilage than either of the other two lots (Table 2). The pan-graded berries, while showing more spoilage than those graded by the pickers, were better in general appearance. The commercially handled berries showed the most spoilage.

TABLE 2.—PERCENTAGE OF SPOILED BERRIES UNDER PAN GRADING AND OTHER METHODS OF HANDLING

	Spoiled berries
	<i>per cent.</i>
Graded by pickers.....	4.20
Pan-graded.....	7.44
Commercially handled.....	9.50

A similar test was made with Dunlap berries from Centralia, Illinois. Special care was taken by the pickers in handling the lot of berries which was graded while being picked. The two other lots were picked in the ordinary commercial manner, but one was pan-graded before being packed. These berries were shipped under refrigeration to Streator, Illinois, and inspected there two days after they were picked.

The berries graded by the pickers were fairly good in general appearance, tho quite a number of the specimens were too ripe or too green. There was a small amount of soft rot and some of the berries were wilted. The boxes were slightly slack. The pan-graded berries were slightly better in general appearance than the preceding lot even tho many specimens were overripe and dark in color, with wilted skin. There was slightly more soft rot than in the lot graded by the pickers, and there were also more bruised berries. Practically all the boxes were full. The general appearance of the fruit was improved by pan grading in spite of the increased amount of bruising and decay. This was due to the removal of the extremely small or green berries. The general appearance of the commercially handled lot was poor and distinctly inferior to that of the two other lots. There were many small berries and green berries present. The amount of soft rot was

about the same as in the pan-graded lot. Most of the boxes were somewhat slack.

In three subsequent tests pan-graded berries were compared with those commercially handled. In all these tests there was considerable bruising of the berries at the tops of the boxes. The amount of bruising was practically the same in the pan-graded and the commercially handled lots. Likewise the general condition of the berries was quite similar. The chief difference between the two lots was in the grade, the pan-graded berries being much superior in this respect. In one of the tests 23 percent of the berries as brought in from the field were sorted out as culls and discarded during the pan grading. The resulting pack was very uniform and was strictly No. 1 stock, which was bright and attractive in appearance upon arrival in market. The commercially handled lot from the same field graded No. 2. Pan grading made it possible to ship good stock even tho the berries as they came from the field were rather poor.

Summer Apples Badly Bruised by Rough Handling

Certain varieties of apples are especially subject to injury by careless handling during picking and packing. Some varieties are more easily bruised than others, and in some the bruises appear much more conspicuous and therefore detract more from the market value of the fruit. The two most important varieties of early apples in Illinois are the Duchess (Oldenburg) and Yellow Transparent. Some tests were made, using these varieties, to determine the extent to which bruising could be prevented by careful handling and the use of other precautionary measures in the picking, grading, and packing of the fruit. The apples were picked at the usual stage of maturity for harvesting these varieties.

One of these tests was made with Duchess apples picked between 8:30 and 10:30 a. m., August 3. One lot of these apples was picked and handled with extreme care. Persons handling the fruit wore cotton gloves. The apples were picked very carefully and placed in half-bushel picking baskets, being graded as they were picked. They were then transferred carefully to bushel shipping baskets and hauled on an orchard wagon $\frac{1}{4}$ mile to the packing shed. There the facing layer of fruit was arranged on each basket and covered with a corrugated paper cap to protect it from the lid. Another lot of fruit in this test was picked and handled in exactly the same manner except that the pickers and packers worked without gloves. For comparison with these two lots, baskets of fruit picked from the same orchard the same morning were taken at random from the packing table. These had been picked, graded over an apple grader, and packed in the usual commercial manner.

The three lots of apples in this test were held in the packing shed until the afternoon of August 4, when they were loaded into an iced refrigerator car, being placed in the top layer of the load near the door. The car was shipped to Cleveland, Ohio, where it was opened and the fruit inspected August 9, six days after it was picked.

Both lots of carefully handled apples carried thru to destination in excellent condition. The fruit showed practically no injury except slight bruises on apples that were pressed against the basket staves or against the rims of the basket and lid. These package bruises were partly due to very tight packing. The two carefully handled lots were so much alike that there was absolutely no evidence of any difference in treatment. Very careful examination of the lot handled without gloves failed to reveal any injuries that could be attributed to the finger nails of the pickers or packers. The use of cotton gloves did not appear to be of any special benefit.

In the lot of fruit that had been commercially picked and packed most of the apples were noticeably bruised — many of them rather severely. The flesh under the skin at the bruised spots had turned brown, thus causing the bruises to become very conspicuous. The appearance of the fruit in these baskets indicated rough handling somewhere in the process of picking and packing. The apples were firm and crisp in texture; bruising was not due to overripeness.

The entire car of apples, outside the carefully handled lots under experiment, appeared to be in practically the same condition as the baskets taken as samples of the commercially handled fruit. This car had been sold on a telegraph order at \$1.25 a bushel delivered in Cleveland. It was rejected because of the bruised condition of the fruit; but according to the consignee it would have been accepted promptly if the car in general had been in the same condition as the carefully handled test packages. The fruit was finally sold for 75 cents a bushel in Cleveland.

Altho no detailed observations were made regarding the methods of handling used in picking and packing the fruit that made up most of this car, it was noticed that the pickers were careless in dumping the apples from picking sacks into field crates; the sound of apples rattling into the crates could be heard 200 to 300 yards away. The pickers seemed to be filling the picking sacks rather full before emptying them. The apples were poured onto the grader with reasonable care, but the grader may have added some bruises to the total. A heavy shower during the previous night left the ground and the fruit quite wet. There seems to be some question as to the effect of such a combination of conditions on the ability of the fruit to resist bruising. The possibility of handling such fruit without severe bruising, however, was clearly demonstrated by the condition of the carefully handled lots upon arrival in market.

Basket Liners Reduced Amount of Bruising. In an attempt to obviate the occurrence of slight bruises caused by pressure of apples against the sides of the basket or against the rim of basket or lid, a test was made in the use of certain types of basket liners and cushions. The apples used in this test were of the Duchess variety from the same orchard and were picked the same day as those in the preceding test. Furthermore, they were picked and handled in the same careful manner as the most carefully handled lot in that test, including the use of cotton gloves by the workmen.

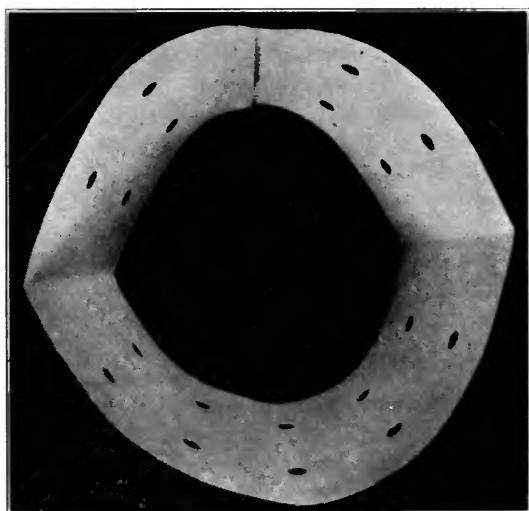


FIG. 4.—VENTILATED BASKET LINER

Such liners afford considerable protection to the fruit from injury by contact with rough places on the basket.

In one of these lots the baskets were lined with ventilated paper liners (Fig. 4); in another lot paper facing cushions (Fig. 5) were used in the baskets. These two lots were shipped to Cleveland in the same car with the apples in the test above reported, and were compared with the carefully handled lots in that test.

When both these lots of apples were inspected in Cleveland, the general appearance of them was excellent. There was very little injury apparent in the lot shipped in baskets equipped with the ventilated liners, except a few slight bruises due to tight packing. The apples against the sides of the baskets showed fewer bruises than similarly located apples in the baskets not equipped with liners or cushions. The liners appeared to be a distinct protection to the fruit

against the sides of the basket. A few specimens were bruised by being pressed against the rims of the basket and lid.

The facing layer of fruit in the baskets packed with facing cushions showed a few slight bruises due to very tight packing. The apples in the facing layer against the rim of the basket suffered less from rim bruises than those packed without liners or cushions, but the apples against the sides of the basket below the facing layer showed about the same amount of bruising as similarly located apples in the baskets without special equipment. The trade did not seem particu-

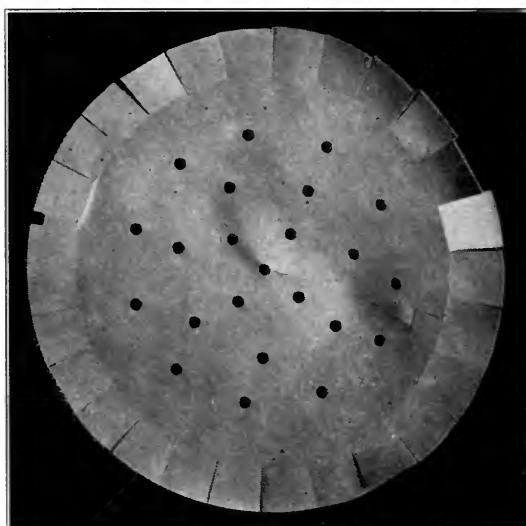


FIG. 5.—PAPER FACING CUSHION FOR BUSHEL BASKET

With the advent of the up-side-down method of packing bushel baskets the opportunity for using cushions of this type has been much reduced.

larly enthusiastic about the facing cushion, and it is doubtful whether its value in protecting the facing layer against rim cuts and bruises justifies its use.

Shaking Baskets During Packing Not Important Cause of Bruising. A question has sometimes been raised regarding the extent of bruising of apples which may be attributable to the process of shaking or racking the baskets of fruit while they are being packed. To secure data on this point a test was made with Yellow Transparent apples at Ozark, Illinois. The fruit was picked at the usual stage of maturity for harvesting the Yellow Transparent variety for ship-

ment.¹ The apples were placed carefully in a picking sack worn by the picker. Care was taken to prevent bruising the fruit against ladder or limbs. The apples were transferred carefully from the picking bag to field crates, and these were hauled very carefully in a light Ford truck to the packing shed. The picking was done between 9:45 a.m. and noon on July 7. In the afternoon the apples were graded carefully by hand and were packed in bushel baskets. All the operations of picking, grading, and packing were carried on by persons wearing cotton gloves.

During the packing of one lot of these apples each basket was shaken or racked to settle the fruit firmly in the container; in the other lot the baskets were not shaken as they were being packed. The car containing these apples was shipped to Montreal, Canada, where the fruit was inspected on July 15.

The general appearance of both these lots of apples was very good when they were examined in the market eight days after they were packed. In the lot in which the fruit was shaken while being packed, the packages were tight and the facing layers smooth. There were very few bruises on apples in the upper part of the baskets; bruises were a little more noticeable in the lower part. On the whole, there were very few bruises as compared with commercially handled fruit shipped in the same car.

In the lot of fruit which was packed without shaking the baskets, the packages were tight and the facing layers fairly smooth, tho not as even as the facing layers in the lot which was shaken. There seemed to be slightly less bruising, especially in the lower part of the baskets, in the lot which was not shaken. The amount of difference, however, was small.

This test indicates that racking or settling the fruit in the basket is not an important cause of bruising in the packing of Yellow Transparent apples.

Careful Handling of Peaches Reduced Amount of Bruising

The relation of careful handling to the carrying quality of Elberta peaches was studied in some tests made with fruit harvested at Centralia, Illinois, in 1926. The fruit used in these tests was picked and packed during the forenoon of August 26, loaded into the top layer of an iced refrigerator car at 2:15 p.m. of the same day, and shipped out the same night. The shipment was delayed in transit, so that final inspection at Cleveland, Ohio, was not made until 3:30 p.m., September 3, eight days after the car was loaded. This gave abundant

¹For shipping to city markets, Yellow Transparent apples are picked before they show any signs of becoming yellow. They are firm in texture and green in color, and the seeds are usually still white.

opportunity for any differences in the carrying quality of the fruit to become evident.

One lot of peaches in these tests was picked and packed in the usual commercial manner, including grading over a machine. Another lot was very carefully handled thruout the entire process of picking, grading, and packing, the work being done by persons wearing cotton gloves. Upon inspection in Cleveland the fruit in both these lots was rather soft and too ripe for best market condition, but no rot had developed. The commercially handled lot showed more bruises than the lot handled with gloves.

Another lot of fruit was carefully handled in exactly the same way as the preceding lot except that the workmen did not wear gloves. This fruit was in practically the same condition as the lot handled with gloves; there was no noticeable difference in the amount of bruising in the two lots and no rot present in either.

To determine the extent of injury to which peaches may be subjected by being run over a grading machine, another lot of fruit was very carefully picked by workmen wearing gloves but was graded over a peach-grading machine. Upon inspection in market this fruit showed slightly more bruising than either of the lots that were carefully picked and graded by hand, but somewhat less bruising than the commercially handled lot, thus indicating that part of the bruising of peaches in commercial handling is received before the fruit reaches the packing shed and part after.

Rot Started at Thumb-Nail Punctures. To obtain information regarding the relation of punctures to the rotting of fruit during shipment, another lot of peaches was very carefully handled by gloved workmen during the picking and grading, but each peach was purposely scratched by the thumb nail as it was packed. The scratching was sufficiently severe in each case to cause a slight puncture or abrasion of the skin. This fruit reached market in the same stage of maturity as the preceding lots, but in contrast to the other lots which showed no evidence of rot whatever, 18 percent of the peaches in this lot showed rot starting in the nail punctures.

Basket Liners Beneficial to Peaches. Tests were also made regarding the effect of facing cushions and ventilated paper liners upon the carrying quality of peaches and their appearance upon arrival in market. One lot of fruit was packed with paper facing cushions and another with ventilated liners in the baskets. In the picking, grading, and packing, these lots of fruit were very carefully handled by workmen wearing gloves, and every possible precaution was taken to prevent bruising. The fruit arrived in market at the same stage of maturity as the preceding lots. Altho there was very little bruising in the top layer of fruit in the baskets packed with facing cushions, the

cushions themselves were soft, wet, and torn in several places where the peaches were not supported from below. The condition of the facing layer made the package of fruit unattractive in appearance.

In the lot of peaches packed with the ventilated basket liners, the fruit against the sides of the baskets did not show as many package marks or bruises as the lot similarly handled but packed without cushions or liners. There was one peach in this lot that showed rot starting from a skin injury.

Overripe Peaches Badly Bruised. The peaches in all the lots so far mentioned were picked at the usual stage of maturity for harvesting Illinois Elberta peaches for shipment.¹ That even very careful handling in picking and packing will not overcome the handicap of too advanced maturity at the time of picking is clearly shown by the condition in which another lot of fruit in this same shipment arrived in market. This fruit was picked and graded by persons wearing gloves, and every care was taken to handle it without bruising. However, at the time of picking, the peaches in this lot had begun to soften slightly and were at a stage of maturity considered too ripe for shipping. When this fruit arrived in market it was extremely soft and altogether too ripe for handling thru the usual merchandising channels. Most of the fruits showed severe bruises where other peaches had pressed against them, and many of the specimens had rotted.

Rhizopus Rot of Peaches Started at Skin Punctures

Further studies regarding the relation of careful handling to the carrying quality of Elberta peaches were made in tests with fruit produced at Villa Ridge, Illinois, in 1927. All the fruit used in these tests was picked from the same orchard between 11 a. m. and 2 p. m., August 1. It was at the usual stage of maturity for harvesting Elberta peaches for shipment. The various lots were handled as follows:

Lot 1. These peaches were picked by the regular orchard crew, hauled to the packing shed at Villa Ridge, run over the grader, and packed in the usual commercial manner.

Lot 2. The peaches in this lot were picked with all possible care by workmen wearing cotton gloves. The fruit was picked into paper-lined buckets and then transferred carefully by hand into the bushel shipping baskets, all the

¹Elberta peaches are picked for shipment as soon as they have reached the "hard-ripe" stage. In commercial practice in Illinois this stage is determined not by any pressure test, either mechanical or with the hand, but by observation of the color. As an Elberta peach approaches maturity, the greenish color of the skin gradually changes to a lemon-colored tint, which later intensifies to an orange-colored shade. These changes in color can more readily be observed on the shaded side of the peach than on the side exposed to direct sunlight where the development of red pigment obscures the undercolor. For rail shipments and handling thru the regular merchandising channels, the fruit should be picked as soon as the lemon-colored stage has been reached.

handling being done by workmen wearing gloves. The baskets were faced and the lids fastened on before the fruit was moved from the orchard. As soon as the packing was completed, the baskets were hauled to the packing shed where they were allowed to stand in the shade until all the lots were ready for loading.

Lot 3. This lot of fruit was picked and handled in exactly the same manner as the preceding lot except that the workmen did not wear cotton gloves while doing the work.

Lot 4. The fruit in this lot was carefully picked in the same manner as Lot 2, by persons wearing cotton gloves. It was then hauled to the packing shed and run over the grader. Each peach in this lot was purposely punctured by the thumb nail of the operator before it was packed. Packing was done by hand.

The four lots of fruit in this experiment were loaded in the top layer near the door in an iced car at 3 p. m. of the day that they were picked. The car was shipped under standard refrigeration to Columbus, Ohio, where notes were taken on the condition of the fruit August 4, three days after the peaches were picked.

The commercially handled fruit in Lot 1 was slightly soft and showed some rather severe bruises, the tissue under them being brown and soft. Most of the bruises were where fruit was pressed against the rim of the lid or basket and in the lower part of the package against the staves, and appeared to have been caused by very tight packing.

While the fruit in Lot 2, handled thruout with gloves, was slightly too soft for best market condition, there were few bruises apparent, and these were mostly against the staves in the bottom of the baskets or in the top layer against the rim. No rot was found in this lot.

The peaches in Lot 3, which had been handled precisely like the preceding lot except that the workmen did not wear gloves, were soft-ripe—too ripe to market advantageously. Altho only a few fruits showed bad bruises, about 10 percent of the peaches in each basket showed brown rot. Rhizopus rot was present on a few specimens. Usually there were no injuries or breaks in the skin to mark the place the brown-rot infection began, but nearly every specimen showing Rhizopus rot showed some skin injury at the point of infection.

The fruit in Lot 4, which had been machine graded and each specimen of which had been punctured by the thumb nail, showed practically no more bruises than Lot 3, and was not quite so ripe as that lot. Rhizopus-rot infections, however, were apparent on 22 percent of the peaches in this lot, and brown-rot infections on 9 percent. Detailed examination of the infected areas, by means of a binocular microscope, failed to show any skin injury that gave a point of infection for brown rot. On the other hand, most of the spots of Rhizopus rot surrounded skin injuries which evidently served as points of entry for the Rhizopus spores. The thumb-nail punctures were the most common points for Rhizopus-rot infection.

The carload of fruit which included this experimental shipment was practically free from brown and Rhizopus rots, excepting about 20 baskets in the two upper layers in the middle of the car. These baskets showed rather high percentages of brown rot with some Rhizopus rot accompanying it.

The most reasonable explanation for the condition observed is that the fruit in these few baskets came from trees where, for some unknown cause, brown-rot control was not satisfactory. These baskets happened to be placed in the middle of the car where temperature conditions were favorable for rapid rot development. It will be noted that altho Lots 2 and 3 were given identical treatment, except for the workmen wearing gloves when handling Lot 2, Lot 2 showed no rot, while Lot 3 showed 10 percent of rot. Detailed examination, as previously noted, failed to indicate skin injuries as the primary cause of brown-rot infection in the decayed specimens. It is probable that these two lots were picked from different trees in the orchard, and that brown-rot control had been ineffective in a tree from which some of the fruit in Lots 3 and 4 were taken. Intimate contact of the fruit in the basket may have caused the brown-rot infection to spread to peaches that were not infected when picked.

It will be noted that relatively little Rhizopus rot was found in Lot 3, whereas Lot 4 contained 22 percent of peaches showing decay due to this organism. This suggests that nail injuries may be a source of serious rot infection if such injuries are numerous and if Rhizopus spores are abundant in the packing shed and on handling equipment.

The fact that Lot 2 showed no Rhizopus rot while Lot 3 did show some injury of this nature, suggests that the use of cotton gloves by those picking and packing Lot 2 may have prevented some injuries which might have permitted Rhizopus infection. Detailed and careful examination of the peaches in Lot 3 which showed Rhizopus injury indicated that practically all of these infections had their beginning in skin injuries of some sort. However, none of these injuries in Lot 3 could be definitely identified as having been caused by finger nails.

Carefully Picked Peaches Damaged During Packing

In order to secure further data regarding the effect of care in the handling of peaches, and particularly to determine, if possible, the exact stage in the handling process at which injury is most likely to take place, some special tests were made with Elberta peaches at Villa Ridge in 1928.

All the peaches used in these tests were picked from the same orchard at the usual stage of maturity for commercial handling early in the morning of August 9. The two bushels of fruit from which Lots 1, 2, and 3 were derived were very carefully picked into half-bushel

picking baskets and were hauled in these containers 1½ miles from the orchard to the packing shed in Villa Ridge. The three other lots (4, 5, and 6) were obtained from fruit that was picked by the regular picking crew and handled in the usual manner practiced in that orchard. The fruit was picked into picking sacks and emptied into bushel baskets in which it was hauled on sleds to a shelter in the orchard; from there it was trucked as soon as feasible to the packing shed at Villa Ridge.

Each of the six lots of peaches consisted of 16 specimens selected at random at a certain stage in the handling process. After their selection the individual specimens were wrapped in tissue wraps and carefully packed in cardboard cartons with a separate compartment for each peach. Each lot was packed in a separate carton.

The peaches to make up Lot 1 were taken from the two bushels of carefully picked fruit as soon as the baskets reached the packing shed. The remainder of this fruit was then run over a peach grader in the usual manner and collected in bushel baskets. Lot 2 was taken out at this stage in the handling process. From the remaining peaches a bushel basket was packed. The Perfection-pack method was used in packing this basket. The basket was then opened and 16 peaches were taken out to comprise Lot 3. Four of these peaches were taken at random from the facing layer, 4 at random from the bottom layer, and 8 at random from the fruit between the bottom and top layers.

The peaches making up Lots 4, 5, and 6 were taken at corresponding stages in the handling process from the commercially picked fruit, Lot 4 being taken at random from fruit that had been commercially picked by the regular crew and hauled by truck to the packing shed, Lot 5 being taken after the fruit had been run over the grader, and Lot 6 after the fruit had been packed in a bushel basket, the selection of specimens in this lot being made in the same manner as in Lot 3.

The six cartons containing the six lots of peaches were packed in a specially designed peach-shipping crate. This crate was placed in a refrigerator car in the afternoon of the day the peaches were picked. It was put on top of a regular 3-layer load of peaches in bushel baskets, and was placed near the door. The car was shipped to St. Louis the following day. On August 14, five days after the fruit was picked, the car was opened in St. Louis and the various lots of fruit very carefully examined.

The fruits in Lots 1 and 2 were in excellent condition at this time. Altho slightly soft, the peaches in these two lots were in good condition for merchandising. Not a bruise was apparent on any of the specimens in Lot 1, which had been taken directly from the picking baskets of carefully picked fruit. Even the fruit that had been run over the grader (Lot 2) showed bruises on only 3 specimens, and

these bruises were very slight and insignificant. There was practically no difference in the condition of Lots 1 and 2. The fruit in Lot 3, however, that had gone thru the regular packing process following very careful picking, showed bruises on all but 2 of the specimens. While these bruises were not severe, they were plainly noticeable as slight discolorations of the flesh and excessive softness at those points.

In the commercially picked fruit the sample which was taken directly from the field baskets (Lot 4) showed slight bruises on 9 of the 16 specimens, while the sample taken after the fruit had passed over the grader (Lot 5) showed similar bruises on 7 specimens. All the bruises in both these lots were small and insignificant and did not materially affect the appearance of the fruit, even tho they were visible as slightly discolored spots, somewhat softer than the rest of the flesh. Both these lots of fruit, while slightly soft, were in good condition for merchandising. It was practically impossible to distinguish any difference between these two lots so far as condition was concerned, and there were nearly the same number of bruises in both lots.

The fruit that had been packed in a bushel basket by the Perfection-pack method, after being commercially picked and graded (Lot 6), showed bruises on all but one peach. In most cases these bruises were more severe than those in Lots 4 and 5, but were not severe enough to detract seriously from the appearance of the fruit. This fruit was still in good merchantable condition.

These tests emphasize the possibility of picking fruit so carefully that no bruises result, while fruit from the same orchard picked commercially may show slight bruises on more than half the specimens as a result of the method of handling before they reach the grading machine.

In these tests no bruising of any consequence resulted from running the fruit over the grader, thus showing the possibility of grading peaches mechanically without damaging the fruit if the machine is operated properly.

The only bruising that produced injury of any consequence occurred during the packing of the bushel baskets. This injury, as pointed out, was not serious, even tho nearly every specimen showed one or more slight bruises.

At the time these test samples of peaches were inspected, two bushel baskets of fruit from the same orchard, handled in the usual commercial manner and shipped in the same car, were examined. This fruit, altho not severely bruised, showed noticeably more of this kind of injury than any of the test samples. Most of the injury seemed to have been caused by the pressure of peaches against one another or against parts of the package.

Peaches frequently reach market showing the results of severe bruising. It is probable that much of such bruising takes place after

the process of packing has been completed. In many instances it is doubtless caused by the continuous pressing of one peach against another in the basket, by the jolting and jarring of the train, and by the added pressure on the fruit in the bottom layer of baskets due to the weight of the fruit in the upper part of the load.

Severe bruising after packing is especially likely to take place when the fruit is past the hard-ripe stage when picked, and toward the end of the trip to market when the fruit has normally softened to some extent. When peaches are picked in the hard-ripe stage and put immediately under refrigeration, they seem to be able to stand a reasonable amount of jolting and jarring without injury.

Delay in Loading Impaired Keeping Quality of Strawberries

Two tests were made to determine the effect of delay in loading strawberries after picking. One test was with Klondike berries at Villa Ridge and the other with the Dunlap variety at Centralia. In each test three pickings were made: one early in the forenoon, one late in the afternoon, and one early the next forenoon. The berries were picked and packed in the usual commercial manner. All three

TABLE 3.—EFFECT OF DELAY IN LOADING STRAWBERRIES

	Spoiled berries <i>per cent.</i>
Loading delayed 32 hours.....	10.45
Loading delayed 24 hours.....	11.94
Loading delayed 8 hours.....	9.50

lots were left in the shade of a packing shed from the time they were packed immediately following picking until the afternoon of the day the last lot was picked. Then the three lots were hauled to the shipping point and loaded into a refrigerator car at the same time. Thus, at the time of loading, the first lot had been picked approximately 32 hours, the second lot approximately 24 hours, and the third lot approximately 8 hours.

The Klondike berries from Villa Ridge were shipped to Minneapolis, Minnesota, where they were unloaded and examined $4\frac{1}{2}$ days after they had been placed in the car. There were marked differences in the condition of the berries when unloaded. Those that had been picked 32 hours before they were loaded had lost most of their luster, and the calyxes were badly wilted. Most of the boxes were slack. There was some decay. The berries that were picked in the afternoon 24 hours before loading were in slightly worse condition than those picked in the morning 8 hours earlier (Table 3). They were dull and wilted in appearance and some of them were soft and leaky. The

calyxes were shriveled. There was some spoilage as a result of bruising. Many of the boxes were slack. The poor condition of these berries was probably due in part to their being picked during the warm part of the day.

The berries picked in the morning of the day they were shipped were in much better condition than the other two lots. The fruit was fairly bright and attractive in appearance; the calyxes were relatively fresh and green; only a few boxes were slack. There was some spoilage due to bruises.

The Dunlap berries from Centralia were sent to Streator, Illinois, and were unloaded there in the forenoon of the second day after they were shipped. There was but little difference in the condition of the two lots of berries that were picked the day before they were shipped. The general appearance of both lots of berries was poor; many berries at the tops of the boxes were dark and wilted, and there was some soft rot in both lots. About the only differences between the two lots were that those picked in the afternoon appeared slightly fresher than those picked in the morning of the same day, and that the boxes were not quite so slack. The berries that were picked the same day they were shipped were in much better condition than the other two lots. Their general appearance was good; most of the berries were firm, fresh, and bright; the boxes were full.

Precooling Improved Appearance of Berries. The feasibility of delaying the loading of strawberries for a few hours and subjecting them to a process of precooling during that period has been suggested. Berries picked during the morning are often not loaded into refrigerator cars until late in the afternoon. Precooling during that period would not delay the actual shipping. Tests were made by means of a small, portable precooling box (Fig. 6) to determine the effect of such treatment upon the carrying quality of the berries.

In a test with carefully handled Aroma berries at Villa Ridge the berries were picked between 7 and 8 a. m. They came from the field at a temperature ranging from 67° F. to 70° F. The air temperature at seven o'clock was 70° F. By 8:30 a. m. the berries had been packed in crates and hauled the short distance to town. Here two crates were put into the precooling box and two other crates left in the shade nearby while the first lot was cooling. The precooling box containing the berries was closed at 9:10 a. m. The temperature of the berries when put into the box was 70° F. Five hours later (at 2:10 p. m.) the box was opened and the berries removed. Their temperature at that time averaged 46° F., while the temperature of the berries left in the shade had risen to 72° F.¹ Thus there was a difference of 26 degrees in the temperature of the two lots of fruit. As soon as the

¹The air temperature at this time was 82° F.

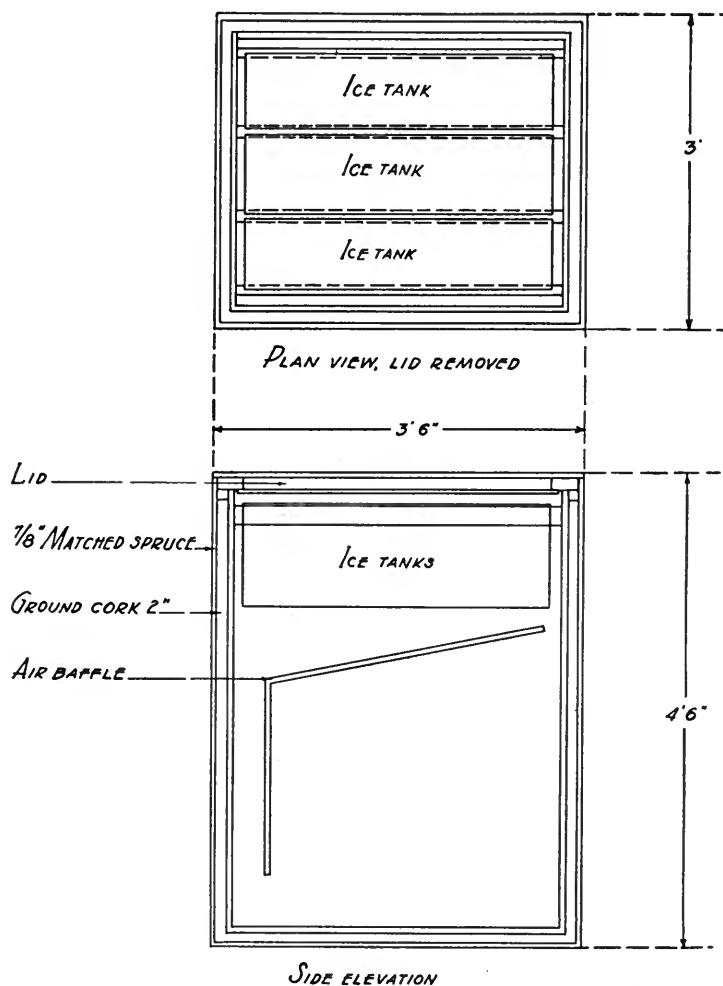


FIG. 6.—PORTABLE PRECOOLING BOX USED IN THESE TESTS

This box was cooled by a mixture of ice and salt placed in the three ice tanks at the top.

crates of berries were removed from the precooling box both lots of fruit were loaded into a refrigerator car. The car was sealed at 3:15 p. m., and shipped out about 7 p. m., June 2. It arrived in Davenport, Iowa, during the night of June 4, and the experimental crates were removed at 6:45 a. m., June 5. The temperature of the berries at that time was 47° F.

The precooled berries were in better condition than those not pre-

cooled. They seemed fresher and their general appearance was better. Some boxes in both lots were a little slack and there was some soft rot and mold in both lots. The percentage of spoiled berries, however, was distinctly lower in the precooled lot (Table 4).

Another precooling test, with Klondike berries, gave less favorable results for the precooling. In this test the berries were picked between 8:30 and 10:30 a. m., and hauled to town at 11:30. At 12:40 p. m. two crates were placed in the precooling box. The temperature of all the berries at that time was 69° F., while the temperature of the air in the shade where the second lot of berries was placed was 79° F. When the berries were removed from the cooler at 4:35 p. m. (after

TABLE 4.—EFFECT OF PRECOOLING ON CARRYING QUALITY OF STRAWBERRIES

	Spoiled berries	
	Aroma	Klondike
	perct.	perct.
Precooled.....	15.65	10.84
Not precooled.....	21.69	8.63

approximately four hours of cooling), their temperature was 56° F. The temperature of the berries that had been standing in the shade was 72° F. The difference in temperature of the two lots was 16° F. Both lots were loaded into a refrigerator car as soon as the precooled lot was taken from the cooling box. The car was shipped out about 7 p. m. and was unloaded in Peoria in the morning of the third day after shipment.

Altho the loss from soft rot and shriveled berries was slightly greater in the precooled lot (Table 4), the general appearance of this lot was distinctly superior to that of the berries which were not precooled. They were brighter in color and most of them were firmer in texture.

Delayed Loading Hastened Maturity of Summer Apples

Delay in the placing of apples under refrigeration, especially if the temperature is high, has long been considered detrimental to the keeping quality of the fruit. Most of the tests made by other workers along this line have been with fall or winter varieties intended for cold storage. That delay in loading the fruit into refrigerator cars after picking is detrimental to the market quality of summer apples, is clearly shown in the results of two tests with the Yellow Transparent variety shipped from Ozark, Illinois, to Montreal, Canada, and to Buffalo, New York.

In each test there were three lots of fruit picked at intervals of approximately 24 hours. All the fruit was loaded into the refrigerator car at the same time, altho the first lot had been picked 48 hours earlier than the third lot. In each test all lots of fruit were from the same orchard and were picked by the regular pickers handling the fruit commercially. Very soon after it was picked, each lot of fruit was hauled to the packing shed at Ozark and there graded and packed into bushel baskets. Care was taken to have the various lots as uniform as possible in reference to stage of maturity at the time they were picked—that being the usual stage of maturity for harvesting this variety for shipment.

The first test was made in 1926 during a period of hot weather. The first lot of fruit was picked early in the afternoon of July 5 and packed between 3 and 4 p. m. It was graded and packed by hand rather than being run over a fruit grader. As soon as it was packed, this lot of fruit was placed against the east wall of the packing shed and was allowed to remain there until the refrigerator car was ready for loading three days later. The second lot was picked early in the afternoon of July 6. This fruit was graded over an apple grader and was packed in the usual commercial manner about 3:30 p. m. It was then placed with the preceding lot against the wall of the packing shed. The third lot was picked early in the afternoon of July 7 and was graded and packed in the usual commercial manner about 3:30 p. m. It was left in the packing shed with the other two lots until about 2:30 p. m., July 8, when all three lots were loaded into an iced refrigerator car in the top layer near the door. This was fully 72 hours after the first fruit was picked.

The air temperature was not recorded on July 5, but the weather was clear, hot, and dry. On July 6, at 7:15 a. m., the temperature of the air in the part of the shed where the apples were being held was 80.5° F.; at 11:15 a. m. it had risen to 93° F.; at about 3 p. m. a thunder shower cooled the air to 75° F. On July 7 the air temperature at 9 a. m. was 83° F., and at 2:15 p. m. it was 94.5° F. The air was sultry and the sky clear.

The car of Transparent apples containing these experimental lots was shipped under standard refrigeration to Montreal, Canada, where the fruit was inspected on July 15, ten days after the first lot was picked. There was considerable difference in the condition of the three lots at that time. Lot 1, which had been in the packing shed nearly three days before it was loaded into the refrigerator car, was fairly good in general appearance tho a few bruises were evident. Most of the apples were turning yellow and were more advanced in maturity than the market desires. Many specimens showed internal browning of the tissues.

Lot 2, which had been held in the packing shed 24 hours less than

Lot 1, was not quite so good as Lot 1 in general appearance, because it showed more bruises, probably on account of the machine grading. This lot showed some yellowish color but was not so ripe on the whole as Lot 1. Also, there was some browning of the flesh, but this was less frequent and less pronounced than in Lot 1.

Lot 3, which had been held in the packing shed 24 hours less than Lot 2, was good in general appearance except for bruises and they were not so conspicuous as in Lot 2. The color was mostly green, tho a few specimens were changing to a whitish tone. In general, the flesh of the fruit was crisp and firm; there was no breaking down or browning of the tissue. This lot was noticeably less advanced in maturity than Lots 1 and 2. However, the entire car of fruit was more mature than is generally desired in Yellow Transparent apples. This was probably due, in part at least, to delay in transit and possibly also to the ice supply becoming low during the trip.

Second Test Substantiated Results of First. Another test in delayed loading of Yellow Transparent apples was made the following year. These also were from Ozark, Illinois. The first lot of fruit in this test was picked late in the forenoon of June 22. It was hauled by truck 4½ miles from the orchard to the packing shed at Ozark, where it was graded and packed by hand. It was then allowed to stand in the packing shed until early in the afternoon of June 24, or approximately 48 hours.

The second lot of fruit was picked late in the forenoon of June 23. This fruit was trucked to the packing shed, where it was graded and packed by hand the same as the first lot and placed with it in the shed. The fruit in the third lot was picked, packed, and handled in precisely the same manner as the two preceding lots except it was picked and packed late in the forenoon of June 24.

Early in the afternoon of June 24, or slightly more than two full days after the first lot of fruit was picked, all three lots were loaded into an iced refrigerator car, being placed in the top layer near the door. The car was closed and sealed that afternoon but was not shipped out until late the next day. The air temperature while the fruit was being held in the packing shed was considerably lower than in the preceding test, the maximum reading for each of the three days being as follows: June 22, 84° F.; June 23, 79° F.; June 24, 81° F.

The car of fruit containing these experimental lots was shipped under standard refrigeration to Buffalo, New York, where it was opened and the fruit inspected at 10:00 a. m., June 29, seven days after the first lot of fruit was picked and five days after the third lot was picked.

Most of the fruit in Lot 1, which had been held in the packing shed for 48 hours before being placed under refrigeration, was fairly ripe, with several specimens quite ripe. There were no signs of in-

ternal browning, however, in any of the fruit. Bruises were not very numerous, but existing ones showed very plainly as brown spots.

The fruit in Lot 2, which had been held in the packing shed for 24 hours, was not so ripe as that in Lot 1, but was somewhat riper than is desirable for market use, even tho the flesh was firm and crisp. Very few of the apples showed bruises.

In Lot 3, loaded within a few hours after picking, the apples had taken on a whitish cast, but all the fruit was firm and crisp and less mature than that in either of the other lots. More bruises showed on the fruit in this lot than in Lot 2, but not so many as in Lot 1. Furthermore, the flesh immediately under the bruises was not so much discolored as in Lot 1, and therefore the general appearance was better.

The results of these two tests are entirely consistent. They show that a delay of 48 hours in getting Yellow Transparent apples from the tree to the refrigerator car greatly hastens the maturing of the fruit and causes it to arrive on the market in the condition known to the trade as "overripe." Furthermore, it may result in internal browning of the fruit. The unfavorable results are likely to be most pronounced in cases where the fruit has been subjected to high temperatures between picking and loading. A delay of 24 hours has the same general effect but in a less marked degree. The longer the delay and the higher the temperature during that delay, the worse is the effect upon the fruit.

Delayed Loading Resulted in Soft Peaches

A test was made to determine the effect of delay in loading upon the carrying quality of Elberta peaches. The fruit was picked at the usual stage of maturity and handled in the customary commercial manner, the only difference in the various lots being in the length of time that elapsed between picking and loading into the refrigerator car. One lot was held in the packing shed for approximately 48 hours before loading; a second lot was held about 24 hours, and the third lot was loaded as quickly as possible after packing.

The test was made with fruit grown at Centralia, Illinois, in 1926. The first lot was picked and delivered at the packing shed early in the afternoon of August 24. It was packed in bushel baskets early in the morning of August 25, and allowed to remain in the packing shed. The second lot was picked early in the afternoon of August 25, packed at 7 p. m. the same day, and allowed to remain in the shed with the first lot. The third lot was picked late in the forenoon of August 26, and packed early in the same afternoon. All three lots were loaded into the top layer of an iced refrigerator car at 2:30 p. m., August 26.

* The car containing this fruit was unloaded in Cleveland, Ohio, on September 3. Notes were taken regarding the condition of the peaches in the various lots on the eighth day after the car was loaded. The fruit that had been held in the packing shed for 48 hours before loading was very ripe and showed some rot. It was entirely too ripe for market use. The fruit that had been held in the packing shed for 24 hours before loading was also overripe but was not so soft as the fruit that had been held 48 hours. There was also less rot in this lot. The fruit that had been loaded within about 4 hours after picking was ripe and fairly soft, but was still in marketable condition. No rot was found in this lot. Altho this fruit would be classed as overripe, it was not so ripe as either of the other two lots, and the advantage of prompt refrigeration was clearly shown.

Temperature of Fruit at Different Times of Day

The advantages of prompt cooling of fruit have been clearly demonstrated. If the fruit is relatively cool at the time it is picked, less time and less refrigeration will be required to reduce its temperature to the desired point than if it is hot when picked. There are marked differences in the temperature of fruit on the tree at different times of the day, depending, of course, quite largely upon changes in air temperature.

Some tests were made to determine the temperature of peaches in the orchard at different times during the same day. Peaches picked at 6:15 a. m. August 14, 1928, showed an average temperature of 72° F. at the time they were picked. Another lot of peaches picked from the same orchard at 10:30 a. m. the same day showed an average temperature of 78° F. Still another lot of peaches picked at 3 p. m. showed an average temperature of 85° F. when picked. The air temperatures in the orchard at the corresponding hours were as follows: 74° F. at 6:15 a. m., 82° F. at 10:30 a. m., 88° F. at 3 p. m. There would probably be considerable advantage in picking peaches early in the forenoon in orchards where the labor force is sufficiently large to keep up with the ripening of the fruit without working all day.

Type of Package May Affect Condition of Fruit

Types of Strawberry Crates. Three types of crates are used in shipping strawberries from Illinois points: the 24-quart Hallock crate, the standard American 24-quart ventilated crate, and the 24-quart collapsible crate. The Hallock crate is not extensively used at present. Each of the other crates is equipped with boxes of the cup or basket type, arranged in three layers of eight boxes each. Wooden "dividers" are used to separate the different layers and to protect the top layer. Both crates are of the ventilated type with slatted sides, tho

the construction is different. The essential differences consist in the condition in which the crates are received from the factory, the manner in which they are set up, and their rigidity after being packed. The standard American 24-quart ventilated crate comes from the factory in either four or seven pieces: two heads or ends, one fabricated piece which constitutes the two sides and the bottom, and one cover; or two heads, two sides, two bottom slats, and one cover.

In setting up this crate, the bottom and sides are securely nailed to the ends, the cross slats of the fabricated piece being broken at the corners by a hammer blow in the crates having the sides and bottom in one piece. This makes a very rigid crate. The other type of crate comes from the factory in three parts. The bottom and the top



FIG. 7.—COLLAPSIBLE OR FOLDING STRAWBERRY CRATES

Such crates come from the factory ready to be set up without the use of nails.

are separate but the sides and ends are hinged together by heavy wire rods. All that is necessary to set up this collapsible crate is to unfold the main part and slip in the bottom. No nails whatever are used (Fig. 7).

Two tests were made to compare these two types of ventilated crates as shipping packages for strawberries. Both tests were made with Aroma berries from Farina. In each test the crates constituted part of a carload of berries loaded in the usual manner. One car went to Peoria, Illinois, and the other to Pittsburgh, Pennsylvania. In both shipments both lots of berries carried thru in good condition except that there was some bruising of the fruit at the tops of the boxes.

There was no apparent difference between the two lots in either shipment. It must be remembered, however, that in both experiments the sample crates were placed in carloads of berries packed in different type crates. This condition would not be comparable to conditions in cars where all the crates were either of the folding type or of the rigid type. Numerous observations in receiving markets have led the writers to conclude that carloads of berries packed in rigid crates are better protected than those packed in folding crates. In cars loaded with rigid crates there is less shifting of the load, air circulation channels are better maintained, and the general appearance of the load is better than in carloads of folding crates.

Suggested Improvement in Construction of Strawberry Crates. The demands of the market require that strawberry boxes be full upon

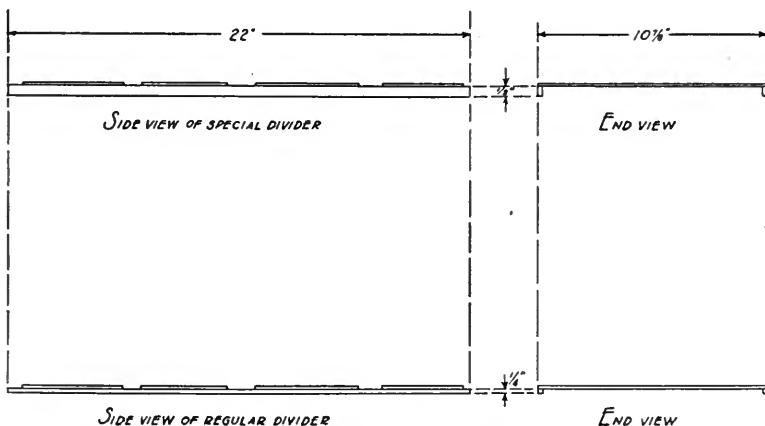


FIG. 8.—COMPARISON OF SPECIAL AND REGULAR DIVIDERS FOR STRAWBERRY CRATES

The special dividers allow one-fourth of an inch more clearance above the tops of the berry boxes. The boxes can be well filled without danger of bruising the fruit.

arrival. During shipment the berries settle considerably. This means that at the time they are packed for shipment the berries must extend considerably above the rim of the box. When packed in this manner in either of the two commercial types of crates above described, the berries at the tops of the boxes invariably become bruised or mashed before arrival in market.

In an attempt to obviate this difficulty special dividers for separating the layers of boxes in the crate were made, and four shipping tests were made in which berries packed in crates equipped with the special dividers were compared with those shipped in crates equipped

with the ordinary dividers. The special dividers were constructed so as to allow $\frac{1}{4}$ -inch more clearance above the rims of the boxes than with the ordinary dividers (Fig. 8). This necessitated making the crates $\frac{3}{4}$ -inch deeper than the standard crate by inserting a cleat at each end to hold up the cover.

In two tests of commercially handled Aroma berries from Farina, Illinois, the fruit packed in the crates equipped with special dividers carried to market in excellent condition; the boxes were full upon arrival in market and the top berries were not bruised or mashed. The fruit shipped in the standard crates arrived in good condition except that the berries at the tops of the boxes were bruised. In these tests the boxes were purposely packed very full.

Two tests were made with Klondike berries from Villa Ridge, Illinois, in one of which the berries were commercially handled and in the other pan graded. In the commercially handled fruit packed in crates with special dividers, no berries at the tops of the boxes were mashed but many of the boxes were slack. They should have been packed fuller. In the comparable lot shipped in ordinary crates, some of the berries in the top layers were mashed, even tho none of the fruit was higher than the top of the box, and some of the boxes were slack. This indicates that the berries settled considerably after they were packed. In the test with pan-graded fruit, the berries in the tops of the boxes in the ordinary crates were mashed and in rather bad condition because of bruises. Considerable mold had developed. Most of the boxes were full. In the pan-graded fruit packed in crates with special dividers, the berries at the tops of the boxes showed no severe bruising tho all the boxes were full. There was no mold.

The use of crates equipped with dividers allowing the $\frac{1}{4}$ -inch extra clearance above the rims of the boxes would make it possible to have strawberries arrive in market with the boxes full without having the top layers of berries bruised or mashed. Only a slight change in the construction of the standard American 24-quart ventilated crate would be required to meet these conditions. Such a change in crate construction would mark a distinct improvement over the crates now in general use.

Tub Bushel Superior to Ordinary Bushel Basket. The straight-sided, tub-bushel type of package is rapidly gaining in popularity as a container for apples and peaches. Two tests were made to secure data regarding the efficiency of this type of package as compared with the ordinary round-bottom bushel basket as a shipping package for Elberta peaches.

The first test was carried on with fruit grown at Centralia, Illinois, in 1926. The peaches were picked during the forenoon of August 26 in the usual commercial manner, and were packed and loaded the same day. The only difference in the handling of the two lots was

that one lot was packed in tub bushels and the other lot in ordinary bushel baskets. The packages of peaches used in this test were loaded in the bottom layer of the car near the doors. Shipment was made under standard refrigeration to Cleveland, Ohio, where the fruit was inspected at 3:30 p. m., September 3, eight days after the car was loaded.

Both lots of fruit arrived in market in good condition and were at the stage of maturity known as "firm-ripe." Altho the fruit in the upper part of the packages in both lots was fairly free from bruising, there was considerably more bruising in the bottom part of the ordinary baskets than in the tub bushels. The fruit packed in the tub bushels was fairly free from bruising thruout the packages.

Similar results were secured in a test made with peaches shipped from Mt. Vernon, Illinois, in 1927. The fruit was picked and packed during the forenoon of August 10, the Perfection packing device being used. It was loaded into the bottom layer of an iced refrigerator car about 2:15 p. m. of the same day and was shipped to Pittsburgh, Pennsylvania, under standard refrigeration. The car was unloaded and the fruit inspected August 15, five days after the peaches were picked.

Both lots of fruit showed general good condition on arrival in market. There was very little bruising of the fruit in the upper part of either type of package. However, in the lower part of the package bruising was noticeably less in the tub bushels than in the round-bottom baskets. There was no more bruising in the bottoms than in the tops of the tubs. The preference given tub bushels as shipping packages for peaches seems to be justified.

SUMMARY AND CONCLUSIONS

1. The customary methods employed in the picking, handling, grading, and packing of Illinois fruits on a commercial basis vary greatly between different operators, but altogether too frequently result in mechanical injury to the fruit before it is shipped, impairment of its carrying quality, and reduction of its market value.

2. Mechanical injury to fruit may take place at almost any point in the process of harvesting and preparation for market. Carelessness on the part of pickers as they grasp the fruit, put it into the picking receptacle, climb down the ladder, or empty the fruit into the field boxes may cause irreparable damage. In loading or unloading the field boxes of fruit or hauling them over a rough road, serious bruising may take place. In pouring fruit into the hopper of a grading machine, in passing it over the machine, or receiving it from the grader into the packing baskets, damage also may occur.

3. Most of the damage could be avoided by proper precautions in the handling of the fruit. In handling fruit a premium should be placed on quality rather than quantity of work accomplished. Two baskets of fruit handled with such speed that every specimen is bruised are likely to yield the grower less net return than one basket properly handled. There is no profit in ruining good fruit by careless handling after it is grown.

4. The pan grading of strawberries, while not adapted to the handling of soft varieties, is perfectly feasible in the case of firm varieties, and if done with proper care, does not damage the berries. It results in a more attractive product that appeals to the trade.

5. The use of basket liners reduces the danger of causing bruises and cuts on peaches and summer apples while they are being packed in bushel baskets.

6. The wearing of cotton gloves while picking and packing peaches and summer apples does not materially reduce the amount of bruising or skin injury as compared with careful handling without gloves. If the finger and thumb nails are kept closely trimmed, there is little danger of skin punctures to the fruit from that source and therefore little danger of unduly exposing the fruit to inoculation with spores of rot fungi.

7. Shaking or racking bushel baskets to settle the fruit during the packing process is not an important source of injury to peaches or summer apples if the fruit is hard and work is done with caution.

8. Fruit that is overripe when picked suffers severely in handling for shipment and is likely to reach the market in very bad condition.

9. Special care is required to pack bushel baskets of peaches and apples at just the right degree of tightness to avoid injury to the fruit in putting on the cover and at the same time prevent slackness in the package after shipment.¹

10. The more quickly fruit can be placed under refrigeration after it is removed from the tree or plant, the better its carrying quality is likely to be. Delay in loading is especially likely to be disastrous if the temperatures are high.

11. The temperature of the fruit when it is picked varies widely at different times in the same day. There are decided advantages in picking the fruit in the morning while it is cool, and placing it immediately under refrigeration.

¹Suggestions on packing apples and peaches respectively are contained in the following publications of the Illinois Agricultural Experiment Station: Bulletin 312, "Marketing Calhoun County Apples"; Circular 343, "Directions for Grading and Packing Illinois Peaches."

12. Precooling strawberries pending shipment may assist in preserving their fresh appearance and enable them to reach market in better condition.

13. A slight change in construction of the standard ventilated strawberry crate so that an additional $\frac{1}{4}$ -inch of clearance above the tops of the boxes is provided, would make it possible to have the boxes full upon arrival in market without having the top berries crushed by tight packing.

14. Fruit packed in "tub bushels" seems less likely to suffer injury in transit than that packed in round-bottom bushel baskets.

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